AgriGrid
A business model concept for next-generation mini-grids in Africa
CONTEXT
Poverty, energy, and agriculture dynamics in Sub-Saharan Africa
The majority of the world’s poor lives in rural sub-Saharan Africa

56% of the people currently living in extreme poverty are in Sub-Saharan Africa

70% of the world’s poor population live in rural Africa

~90% extremely poor people will live in Sub-Saharan Africa, by 2030

55% of households in sub-Saharan Africa lack electricity access

In 2019
An estimated **573 million people in Sub-Saharan Africa** lack access to electricity

In 2030
Without dramatic changes in energy access, **600 million people in Africa** will lack access to electricity

Africa imports USD 50 billion of food each year

The food import bill for sub-Saharan Africa is expected to be **USD 48.7 billion in 2019**, up 3.8% from USD 46.9 billion in 2018⁵

Food imports in Africa are expected to grow to over **USD 110 billion by 2025**⁶

Consumer demand for food products in Africa will exceed **USD 700 billion by 2030**

Sources:
1. FAO STAT
Crop yields in Africa are a fraction of global averages

Cereal* yield (kg per hectare) in 2017

Africa has more than 50% of the world’s fertile and unused arable land

Average fertilizer use in Africa is 17kg per hectare of arable land, compared with a global average of 135 kg

Agricultural yields are 56% of the international average

Cereal* production (metric tons) - Sub-Saharan Africa, OECD members, World

Note:
*Cereal includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains

Sources:
2 MDPI, Raising Crop Productivity in Africa through Intensification, 2017, p1
These challenges are seen throughout sub-Saharan Africa

- Rural areas remain economically disadvantaged
- Growth in domestic food demand is outstripping domestic supply
- There is a major need for modern and decentralized energy solutions
- Domestic agricultural systems require transformation
2. INTRODUCING AGRIGRID

A business model concept integrating agribusiness with mini-grid electrification
AgriGrid businesses export* value-added products to external markets while also selling modern energy services.

1. AgriGrid Operator installs and operates mini-grid and sells energy services to community.
2. AgriGrid Operator develops and agricultural strategy, and purchases raw food & ag products from community.
3. AgriGrid Operator refines raw food & ag products and sells value-added food & ag products to external markets.
4. AgriGrid Operator and Community Organization manage a profit-sharing arrangement with the community.

* “Export” refers to the sale of commodities produced in rural communities to any external market, including domestic urban markets.
Several levers are used to create economic value and increase export revenue in electrified villages

1. Increased crop yield, diversity, intensity
2. Extra harvest season for income smoothing
3. Production of modern, commercial grade food and agricultural products
4. Reduction in losses, pricing power, access to new markets
5. Reduction in losses, entrance to formal sector, access to new markets
6. Reduction in losses, entrance to formal sector, access to new markets
7. Institutional infrastructure for convening, training, revenue sharing
8. Business analytics for decisions, optimization, reporting
9. Agricultural sales, technical partners, marketing, capital, legitimacy

- Crops, Inputs, & Practices
- Irrigation
- Commercial -scale processing
- Storage
- Packaging
- Transport & Sales to External Markets
- Community Organization
- Connected Systems
- Commercial Networks
A set of food and agricultural operations are added to the mini-grid development lifecycle

<table>
<thead>
<tr>
<th>Modern Mini-Grid Operations</th>
<th>Pre-construction</th>
<th>Construction</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mini-Grid Site Assessment</strong></td>
<td>Technical, social, economic assessment</td>
<td>Design and construction of generation, storage, distribution, metering</td>
<td>Sale of energy, appliances, equipment, other goods and services</td>
</tr>
<tr>
<td><strong>Community Engagement</strong></td>
<td>Introduction to modern energy services, community buy-in</td>
<td></td>
<td>Technical and commercial support</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional Operations Under an AgriGrid Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food &amp; Agri Opportunity Definition</strong></td>
</tr>
<tr>
<td><strong>Agri Community Organization</strong></td>
</tr>
<tr>
<td><strong>Agri Site Assessment</strong></td>
</tr>
<tr>
<td><strong>Agri Strategy &amp; Partnerships</strong></td>
</tr>
<tr>
<td><strong>Agri Training</strong></td>
</tr>
</tbody>
</table>

Agri **Energy Services Sales**

Agri **Ongoing Support**

Agri **Purchasing**

Agri **Revenue Sharing**

Agri **Processing**

Agri **Sales**
3 WHY AGRIGRID?
Targeting rural prosperity and strengthening mini-grid business models

© ANKA Madagascar
Food and agriculture is a major potential source of wealth creation for rural areas

60% of arable land is in Africa

Only 4% of arable land in Sub-Saharan Africa is irrigated

Average fertilizer use in Africa is 17kg per hectare of arable land, compared with a global average of 135kg

Agribusiness in Africa is a $1 trillion opportunity

Sources:
2 http://www.ifpri.org/blog/irrigating-africa
Rural areas in Africa are often marginalized and excluded from agricultural wealth. Here are the characteristics and long-term outlooks for rural areas, domestic food and agriculture networks, and urban areas:

### Rural Areas
- **Characteristics**
  - Low income, agrarian communities
  - Limited access to information and knowledge of best practices
  - Limited access to inputs
  - Limited access to finance
  - Limited access to markets
  - Off-grid with limited infrastructure
- **Status quo**
  - At the mercy of informal traders and middlemen
- **Long-term outlook**
  - Likely to remain economically disenfranchised and fragile without enhanced farmer protection

### Domestic Food and Agriculture Networks
- **Characteristics**
  - Strong presence of informal, opportunistic and exploitative operators
  - Inefficient operations with limited incentive to modernize or optimize
  - Often simple and low CAPEX trading businesses
- **Status quo**
  - Inefficient systems with unrealized technical potential and large losses
- **Long-term outlook**
  - Likely to remain fragmented without major investments by formal actors

### Urban Areas
- **Characteristics**
  - Expanding populations
  - Emerging, aspirational middle class
  - Increasing purchasing power
  - Increasing demand for quality food and beverages
- **Status quo**
  - Growing demand met by cost competitive food imports
- **Long-term outlook**
  - Likely to continue to favor imports over costly or low quality domestic products
Mini-grids are an important electrification solution for rural Africa but can be challenging investments.

Modern Mini-Grid Investments in Africa

- High Average Investment Per User
- Low Average Revenue Per User
- Uncertainty in load and revenue forecasting
- Limited economic activity precludes demand growth
- OPEX floor reduces site profitability
- Uncertain interactions with utilities and national planning
- Uncertain and dynamic regulatory environments
- Dynamic subsidy and capital environments
- High WACC reflecting several sources of investment risk
Site-level difficulties have limited* the scaling and impact of mini-grids in Africa to date

- Mini-grids are deployed in low-income communities with irregular cashflows.
- The sizing of generation and storage is challenging due to seasonality and uncertainty in load forecasting.
- Tariff designs require experimentation to test acceptance with price-sensitive communities.
- Long-term growth in energy demand is difficult to forecast and rarely matches estimates.
- Site-level investment performance remains poor, making it difficult for developers to access additional resources to scale.

*Note: The scope of this note is limited to site-level economics. It does not discuss broader but also critical challenges affecting mini-grids such as: licensing, regulation, financing/subsidies, and other aspects of the investment climate.
Fortunately, standardization is enabling commercial experimentation: “Mini-Grids 3.0” and beyond

**Mini-grid 1.0**
- Serving Rural Customers

**Mini-grid 2.0**
- Building Smart Businesses

**Mini-grid 3.0**
- Accelerating Investment

**Mini-grid 4.0**
- Enabling Digital Economies

**AgriGrid**

**TECHNOLOGY**
- Simple demonstrations
- Smart tariffs, remote O&M
- Consolidation of smart technologies
- Digital integrations

**VENTURE**
- Experimentation in market segments, B2B/B2C customer mixes, tariff designs, OPEX reductions, bundling/financing, corporate structures
- Nexus/cross-sector innovation between mobility, water, food & agriculture, ICT

**MARKET**
- Identification of investment climate requirements
- Global, regional, and country market readiness, new financing facilities, public subsidies programs, market acceleration initiatives
- Market standardization / maturation
Mini-grid companies bring valuable resources and capabilities that can be leveraged to ease constraints in agribusiness

Relevant strengths of mini-grid companies

- Commercial and technical expertise
- National and international recognition
- Visibility and credibility
- Business networks and partners
- Smart technologies
- Ability and ambition to operate at scale
- Formal business practices
- Social impact-orientation

African agricultural commodity value chains face common constraints

<table>
<thead>
<tr>
<th>Under-Performing Value chains</th>
<th>Insufficient utilization of inputs and mechanization</th>
<th>Limited reach of to boost on farm production</th>
<th>Poorly organized post aggregation and transport</th>
<th>Inconsistent capacity for effective value addition</th>
<th>Poorly developed market linkages trade corridors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient Infrastructure</td>
<td>Insufficient transport, energy, water and others hard infrastructure leading to uncompetitive cost structures</td>
<td>Underdeveloped soft infrastructure aging smallholder farmers and lack skills commercial agriculture and agro-allied industries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited to agriculture finance</td>
<td>Real and perceived risk limiting private sector investment</td>
<td>High service cost due to small deal sizes, lack of data, and low capacity in agriculture lending</td>
<td>Limited market attractiveness relative to perceived higher returns outside of the agriculture sector</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source:
Mini-grid companies bring valuable resources and capabilities that can be leveraged to ease constraints in agribusiness

### Relevant strengths of mini-grid companies

- Commercial and technical expertise
- National and international recognition
- Visibility and credibility
- Business networks and partners
- Smart technologies
- Ability and ambition to operate at scale
- Formal business practices
- Social impact-orientation

### African agricultural commodity value chains face common constraints

<table>
<thead>
<tr>
<th>Adverse agri-business environment</th>
<th>Unfavorable access and incentives limiting trade and capacity to produce high-quality products</th>
<th>Ineffective sector regulation creating long lead times for new technologies inconsistent trade policies</th>
<th>Unsupportive business enabling environment restricting land tenure and general ease of doing business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited inclusivity, sustainability and nutrition</td>
<td>Insufficient inclusivity of women and youth in agriculture development</td>
<td>Limited incentives to ensure sustainability and climate-resilient practices.</td>
<td>Limited access and affordability of commodities with high nutrition levels</td>
</tr>
</tbody>
</table>

Source:
Mini-grid companies navigate several unknowns when identifying, assessing, and designing new sites

**Who to connect to the grid?**
- What mix of anchor, institutional, micro-enterprise, and household customers to connect?
- Who is too far from the mini-grid?
- Who is best served by an SHS?

**How to design tariffs and forecast long-term pricing?**
- How to design a tariff structure for differing customer segments?
- How will communities and customer behavior change once over time?
- How will communities react to tariff changes?

**How to manage seasonality?**
- How can we increase demand for electricity over the long-term?
- How can we manage low consumption during low-income seasons?
- How can we smooth Abilities to Pay (ATP) and/or energy consumption throughout the year?

**How to size and time CAPEX?**
- How much generation and storage capacity to install?
- How much capacity to install now vs. later?
- How to ensure that electrical equipment and appliances are available in the community?
By creating rural wealth, AgriGrid operators mitigate key mini-grid investment risks

**Who to connect to the grid?**
- By providing access to market for agricultural commodities, a greater number of households will be able to afford connection fees and electricity purchases.
- Some households will remain untenable for mini-grid connection due to their location.

**How to design tariffs and forecast long-term pricing?**
- Greater disposable income provides certainty around increased household demand for electricity.
- Commercial loads from agricultural infrastructure can be accurately forecasted during business planning.
- The existence of a community organization that is connected to agriculture and energy operations can mitigate social risks.

**How to manage seasonality?**
- Greater income increases household resilience and the ability to save during low-income seasons.
- AgriGrid operations can be designed with multiple food & ag value chains to smooth incomes and load year-round.

**How to size and time CAPEX?**
- Increased incomes enables greater certainty in ability to pay for electricity.
- Installing a large commercial processing facility to support a viable agribusiness decreases error margins in capacity planning.
- Providing market linkages ensures that equipment and appliances are paid off.
The model alleviates challenges in crop productivity, rural incomes, energy access, and food systems

<table>
<thead>
<tr>
<th>Modern Mini-Grid</th>
<th>AgriGrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low agricultural productivity</td>
<td>• Optimized agricultural productivity</td>
</tr>
<tr>
<td>• Low and irregular household incomes</td>
<td>• Increased and smoothened incomes</td>
</tr>
<tr>
<td>• Limited ATP* for energy services</td>
<td>• Greater disposable income for energy consumption</td>
</tr>
<tr>
<td>• Limited growth in energy demand</td>
<td>• Economically growing communities</td>
</tr>
<tr>
<td>• Economically fragile communities</td>
<td>• Financially valuable agribusiness companies</td>
</tr>
<tr>
<td>• Financially fragile mini-grid companies</td>
<td></td>
</tr>
<tr>
<td>• Informal, exploitative, inefficient agribusiness industry</td>
<td>• Modern, efficient, and commercial-scale agribusiness</td>
</tr>
<tr>
<td>• Unmet consumer demand for food</td>
<td>• Consumption of domestic products</td>
</tr>
<tr>
<td>• Net food importer</td>
<td>• Net food exporter</td>
</tr>
<tr>
<td>• Government food subsidies</td>
<td>• Government FX revenue</td>
</tr>
<tr>
<td>STRENGTHS</td>
<td>WEAKNESSES</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| • Increased household incomes in rural areas  
• Increased household energy consumption  
• Improved load forecasting  
• Decreased effects of seasonality  
• Increased development impact  
• Improved investment performance  
• Greater trust with communities  
• Increased national economic benefits | • Need for agribusiness and mini-grid expertise  
• Increased CAPEX and OPEX requirement  
• Complex, site-specific project designs and models  
• Multi-party/partner commercial risks  
• New regulatory risks (food and agriculture)  
• Inter-/intra-company tradeoffs |

<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>THREATS</th>
</tr>
</thead>
</table>
| • High value international export opportunities  
• Multi-value chain product strategies  
• More attractive financing terms and envelopes  
• Transformation of local communities  
• Creation of industrial clusters  
• Integration with national energy, food, and agro-industrial investment planning  
• Leveraging food, agriculture, and nutrition resources for energy access aims | • Competitive pressures in food and ag markets  
• Dependency on seasonal commodities  
• Climate risks: floods, pests, crop disease, drought  
• Pricing risks of agricultural commodities  
• Community risks of profit sharing models  
• Risk of disenfranchising existing traders  
• Challenging to secure partners due to complexity |

While the AgriGrid model may create long-term value, operational risks also increase.
Assessing an AgriGrid opportunity in rural Madagascar
Approach: Exploring an AgriGrid at “MadaSite”

Market analysis
- We assessed domestic consumer demand in Madagascar for food and agriculture products only. This was to bound the analysis and avoid assessing high-value export opportunities which could be endless and uncertain.
- We used national food import data as a proxy for domestic consumer demand.

Site selection
- ANKA Madagascar has a large mini-grid site pipeline at various stages. We combined existing site data with the outcomes of the national food & agriculture market analysis.
- We medium-listed 8 sites and shortlisted 3 potential sites for rapid scans.
- We collected food & agricultural data from the 3 shortlisted sites and selected one (“MadaSite”) for a more detailed, deep dive analysis.

Base case
- We used data from an existing ANKA Madagascar feasibility assessment to create a “Base Case” for MadaSite.
- The assessment included specifications for the mini-grid design, investment sizing, financial projections, and impact projections.

AgriGrid case
- We assessed food & agriculture value chains in MadaSite to identify opportunities for value creation/addition and household income growth.
- We prototyped an AgriGrid business model, researched key technical and commercial needs, and collected additional site data as required.
- We modeled an “AgriGrid Case” at a pre-feasibility level of assessment.

Case analysis
- We compared the “Base” and “AgriGrid” cases across financial, economic, and impact KPIs.
- We assessed whether the investment opportunity is attractive enough to take forward.
Madagascar imports USD 760 million of food and animal products annually – roughly 6% of GDP.
Site Selection: Exploring fit with existing sites

**Potential Pipeline Sites**

- Sites in the North
- Sites in the South

**Basic Site Analysis**

<table>
<thead>
<tr>
<th>Site</th>
<th>Area</th>
<th>Population</th>
<th>Infrastructure</th>
<th>Opportunities</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiteA</td>
<td>1000</td>
<td>100,000</td>
<td>Good</td>
<td>High</td>
<td>Growth, Employment</td>
</tr>
<tr>
<td>SiteB</td>
<td>5000</td>
<td>500,000</td>
<td>Excellent</td>
<td>Medium</td>
<td>Education, Tourism</td>
</tr>
</tbody>
</table>

**Initial Site Scoring**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>SiteA</th>
<th>SiteB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Security</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Climate</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Note: Site names are anonymous and image resolution is low for data confidentiality.
### Site Selection: 3 sites shortlisted sites for Rapid Scans

#### Site 1
- **1,000 Households**
- **07 Schools**
- **09 Churches**
- **01 Clinic**
- **20 SMEs**

**Mini-grid specifications**
- 325 kW solar PV
- 110 kVA diesel
- 900 connections

**Food & Agriculture**
- Carrots; cabbage; potato; tomato; ginger; khat; poultry

#### Site 2
- **1,080 Households**
- **03 Schools**
- **08 Churches**
- **01 Clinic**
- **10 SMEs**

**Mini-grid specifications**
- 176 kW solar PV
- 110kVA diesel
- 700 connections

**Food & Agriculture**
- Cocoa; rice; sweet potato

#### Site 3
- **1,262 Households**
- **05 Schools**
- **06 Churches**
- **01 Clinic**
- **15 SMEs**

**Mini-grid specifications**
- 195 kW solar PV
- 110 kW diesel
- 800 connections

**Food & Agriculture**
- Rice; tomato; banana; mango; sugarcane
For each of the 3 shortlisted sites, our field team gathered data on existing food & agriculture activities. We coupled this data with pre-existing site feasibility assessments. We looked at other generic factors - such as road access, presence of commercial ag players, proximity to demand centers, and more – to select the site for a deeper dive.

Note: Ideally, we would have assessed a cluster of sites to achieve economies of scale. We considered this out of scope for this R&D project due to limited time and budget.
**General Site Information**

- **1262** Households
- **05** Schools
- **06** Churches
- **02** Clinics
- **15** Rice huskers
- **Poor** network coverage
- **12** km from paved road
- Closest town: 13 km
- Head of region: 145 km
- Capital: 990 km
- Daily bus and rickshaws to closest town
- Nearest grid: 13 km

**Agricultural Information**

**Rice value chain**

**Mangoes value chain**

**Mini-Grid Specifications**

- 195 kW Solar PV
- 110 kVA Diesel
- 252 kWh Li-ion storage
- 14.5 km LV network
- 800 connections
  - 780 1-Phase connections
  - 20 3-Phase connections
A 192 kWp Solar PV/Diesel hybrid project at MadaSite performs as a conventional modern mini-grid.

**Customers**
- Number of phase 1 users: 983
- Number of phase 3 users: 12

**Total Generation Assets**
- Solar PV incl. mounting system: 192 kWp
- Diesel generators: 140 kVA
- Battery: 252 kWh
- PV inverter: 170 kVA

**Total Distribution Assets**
- LV distribution grid: 14.2 km
- MV distribution grid: – km

**Funding Sources USD**
- Grant: USD 543,089
- Village Contribution: – USD
- Senior Debt: USD 243,636
- Equity: USD 131,188
- Total: USD 917,913

Financed with

Translating into

Investment and Project Performance*

**Returns**
- Forecast period: 25 years
- Equity IRR (US$ based): 17.33%
- Project IRR (MGA based): 19.5%
- Project NPV: USD 227,086
- Payback (yrs): 10

*Capital structure = 55% grant, 15% equity, 30% debt; equity IRR = 12%, WACC = 12.5%.
The main and existing agricultural value chains include rice, tomato, banana, mango, and sugarcane.

<table>
<thead>
<tr>
<th></th>
<th>Market potential</th>
<th>Social impact</th>
<th>Scale and replicability</th>
<th>Seasonality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>★★★</td>
<td>★★★☆</td>
<td>★★★☆</td>
<td>★</td>
</tr>
<tr>
<td>Banana</td>
<td>★★</td>
<td>★★★☆</td>
<td>★★★☆</td>
<td>★</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
<td>★</td>
</tr>
<tr>
<td>Tomato</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
<td>★</td>
</tr>
<tr>
<td>Mango</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
<td>★</td>
</tr>
</tbody>
</table>

**High potential**
- 90% of farmers in the village grow rice
- There are 2 harvest seasons, smoothing incomes
- Rice is the main staple crop in the country, so the opportunity is highly scalable to other sites
- Rice millers want electricity to replace diesel
- Many other sites have high banana production
- Bananas can be processed into juice or dried fruits
- Bananas grow almost year-round
- There is a sugar company near the site
- Around 50% of the farmers grow sugarcane
- Few areas in the country produce sugarcane

**Result:**
We selected the rice value chain as the lead value creating opportunity in MadaSite. Rice is grown throughout the country however there is minimal value addition in rice value chains. Madagascar imports USD 118 million of cooking oil, for which domestically produced **Rice Bran Oil (RBO)** can be a competitive substitute.
AgriGrid case: Food & ag analysis at MadaSite

**Production**
- Farmers

**Processing**
- Farmers
- Rice mill business owner
- Local traders
- Regional aggregators
- Polished rice
- Rice bran

**Market**
- Farmers
- Local traders
- Regional aggregators (i.e. from other villages/cities)
- Local poultry farms
- Regional aggregators
- Poultry feed factory

**Value Chain Activities**
- Irrigation
- Paddy rice
- Storage
AgriGrid Case: Producing RBO at MadaSite on a rather small scale with max. 20 MT per day during high season

- Number of local rice huskers: 29
- Average rice bran processed during HIGH SEASON per husker: 20,0 MT
- Average rice bran processed during LOW SEASON per husker: 7,0 MT
- Average volume of rice bran per husker: 123,0 MT
- TOTAL rice bran production: 3567,0 MT
- Purchasing price from rice dehuskers: MGA/MT
- Rice husker inclusion rate: 10,0%
- Total annual rice bran yield: MTA MT
- Losses and wastage: 20,0%
- Net annual production volume: 642,1 MT
- Rice bran oil content:
  - %: 20,0%
  - MT/MT: 642,1
- Rice bran oil volume p.a.: 20,0%

Annual sales of more than 1 billion MGA p.a. both to local shops and to wholesalers (equivalent to USD 280k)
AgriGrid Case: Assumptions

Market
- Households would adopt RBO at a competitive price
- Household cooking oil consumption of 2 liters/month
- Sales territories and the storage facility sized such that RBO sales were possible year-round

Business Design
- Mini-grid and RBO investments are shared by one entity
- O&M of mini-grid and RBO assets provided by one entity
- Rice bran catchment area limited to electrified mills (29)
- RBO factory receives free electricity (i.e. self-consumption)
- RBO sold to retailers outside of MadaSite
- RBO profits are shared 50/50 with community association
- Community association allocates RBO profit share in cash (i.e. not in-kind)
- Households maintain % energy expenditure

Energy
- System size not affected – simply less excess capacity
- Distribution network design not affected - lower number of household connections than Base Case
- Increase in household energy consumption ~ increase in disposable income

Rice Bran Oil
- 50% of existing bran would be available for purchase
- No bran storage, but storage for RBO
- Operations of 300 days/year
- 10% loss between bran supply and produced RBO
AgriGrid Case: Prototype project design

Madasite Community

Electricity users connected to MadaSite mini-grid

- Public Facilities
- Productive Users
  - Rice Mills
  - White Rice
  - Rice
- Households
- AgriGrid Co.
  - Rice Bran Oil Factory & Warehouse
  - Training, ag inputs, infrastructure
  - Processed Rice Bran Oil
  - Cash

Retailers of Rice Bran Oil

ANKA
Madagascar
Mini-Grid
O&M
Unchanged number of productive users (apart from rice bran oil processing plant as internal consumption) but increased power production capacity.

Customer:
- Number of phase 1 users: 983
- Number of phase 3 users: 13

Total Generation Assets:
- Solar PV incl. mounting system: 280 kWp
- Diesel generators: 230 kVA
- Battery: 340 kWh
- PV inverter: 250 kVA

Total Distribution Assets:
- LV distribution grid: 14.2 km
- MV distribution grid: – km

Funding:
<table>
<thead>
<tr>
<th>Source</th>
<th>USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant</td>
<td>885.238</td>
</tr>
<tr>
<td>Village Contribution</td>
<td>–</td>
</tr>
<tr>
<td>Senior Debt</td>
<td>400.137</td>
</tr>
<tr>
<td>Equity</td>
<td>215.458</td>
</tr>
<tr>
<td>Total</td>
<td>1,500.833</td>
</tr>
</tbody>
</table>

Financed with

Translating into

Investment and Project Performance:

Returns:
- Forecast period: 25 years

Equity:
- Equity IRR (US$ based): 14.40%
- Project IRR (MGA based): 17.3%
- Project NPV: 228,438 USD
- Payback (yrs): 10 years

*Capital structure = 50% grant, 25% equity, 25% debt; WACC = 6%
Unchanged number of productive users (apart from rice bran oil processing plant as internal consumption) but increased power production capacity

**Customers**
Number of phase 1 users: 983
Number of phase 3 users: 13

**Total Generation Assets**
- Solar PV incl. mounting system: 790 kWp
- Diesel generators: 650 kVA
- Battery: 340 kWh
- PV inverter: 700 kVA

**Total Distribution Assets**
- LV distribution grid: 14.2 km
- MV distribution grid: – km

**Funding**
Sources USD
- Grant: USD 3,701,417
- Village Contribution: USD –
- Senior Debt: USD 1,420,588
- Equity: USD 764,932
- Total: USD 5,886,937

*Capital structure = 50% grant, 25% equity, 25% debt; WACC = 6%*

**Investment and Project Performance**
- Forecast period: 25 years
- Equity IRR (US$ based): 34.53%
- Project IRR (MGA based): 27.2%
- Project NPV: USD 2,085,774
- Payback (yrs): 5
### Limitations of the AgriGrid Case analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Limitations</th>
</tr>
</thead>
</table>
| **Agricultural Modelling**      | • Other, higher potential market opportunities for increasing “export revenue” likely exist. We selected the cooking oil market to illustrate here due to established demand and clear information on retail pricing.  
• There are several additional options for agricultural value creation in other value chains. We limited our analysis to new product development based on existing value chains. |
| **RBO Production and Retail Marketing** | • We assumed that Malagasy households would purchase RBO as a cooking oil substitute.  
• RBO is not a simple oil; it involves complex processing which we simplified in our analysis.  
• There are several retail options which we brainstormed but did not explore. We simplified retail operations by indicating a retail price competitive with existing oils and used an industry standard profit margin. |
| **Energy System Modelling**     | • We did not materially adjust the mini-grid design between the two cases. This is likely not realistic.  
• Since we did not adjust energy system dimensions, we instead estimated trade-offs for # connections, consumption, and revenue. |
| **Community and Household Modelling** | • We assumed households and rice millers would willingly sell rice bran to the AgriGrid operator in exchange for profit-sharing.  
• We assumed that electricity consumption would rise with increased incomes. |
Comparing a mini-grid vs. AgriGrid with different sizes at MadaSite

The proposed AgriGrid project design increases development impact and investment performance but only at large scale

<table>
<thead>
<tr>
<th>Performance</th>
<th>Mini-grid case</th>
<th>Small AG case</th>
<th>Large AG case</th>
<th>Deviation L-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average EBIT margin %</td>
<td>19.1</td>
<td>12.1</td>
<td>12.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Equity IRR %</td>
<td>17.3</td>
<td>14.4</td>
<td>34.5</td>
<td>20.1</td>
</tr>
<tr>
<td>Equity NPV USD</td>
<td>101,793</td>
<td>67,299</td>
<td>1,364,551</td>
<td>1,297,252</td>
</tr>
<tr>
<td>Equity payback years</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>-5</td>
</tr>
<tr>
<td>Cumulated flow to equity USD</td>
<td>1,036,323</td>
<td>1,240,415</td>
<td>6,364,811</td>
<td>5,144,396</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Funding</th>
<th>Mini-grid case</th>
<th>Small AG case</th>
<th>Large AG case</th>
<th>Deviation L-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants for assets USD</td>
<td>543,089</td>
<td>885,238</td>
<td>3,701,417</td>
<td>2,816,179</td>
</tr>
<tr>
<td>Grants for first loss USD</td>
<td>83,727</td>
<td>130,901</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Village contribution USD</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Senior debt USD</td>
<td>243,636</td>
<td>400,137</td>
<td>1,420,588</td>
<td>1,020,451</td>
</tr>
<tr>
<td>Equity USD</td>
<td>131,188</td>
<td>215,458</td>
<td>764,932</td>
<td>549,474</td>
</tr>
<tr>
<td>Total</td>
<td>1,001,640</td>
<td>1,631,734</td>
<td>5,886,937</td>
<td>4,255,203</td>
</tr>
</tbody>
</table>
• **We decided not to continue with a full feasibility assessment of the RBO opportunity.** While attractive, RBO production appears technically complex, requiring sophisticated supply chains and high volumes.

• Were we to continue with the RBO value chain, **a full feasibility study would include:** consumer taste testing of RBO, an assessment of food and ag regulations, detailed sales channel research, deeper technical and operations research, and deeper supply chain research and modeling.

• **We would require an RBO technical expert and community development expert** to complete a full feasibility assessment.

• **We would further assess the governance model.** A joint venture or partnership may be preferable to a fully integrated entity.

• **Going to scale with the RBO value chain will create funding challenges.**

• Instead, we investigate other value chains that are **less complex, less challenging in terms of investment and operationalization, and more easily replicable.** A pilot is being developed for commissioning in 2021.